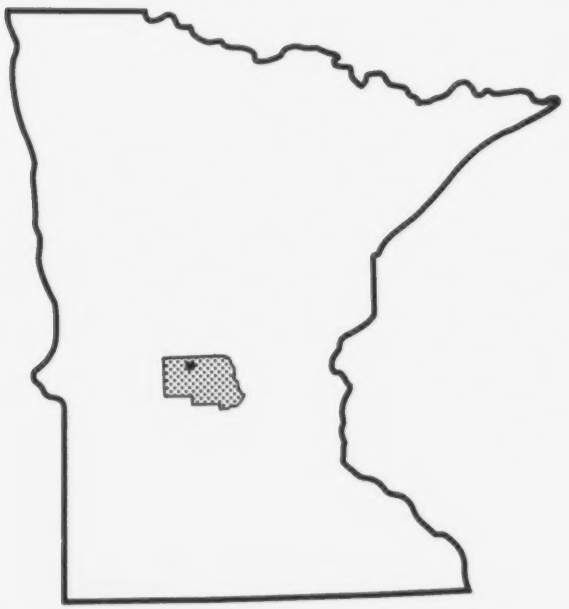
270459

FLOOD INSURANCE STUDY

CITY OF SAUK CENTRE, MINNESOTA

STEARNS COUNTY



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Sauk River Panel 01P

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Flood Boundary and Floodway Map

PUBLISHED SEPARATELY:

Flood Insurance Rate Map Index
Flood Insurance Rate Map

FLOOD INSURANCE STUDY

CITY OF SAUK CENTRE, STEARNS COUNTY, MINNESOTA

1.0 INTRODUCTION

1.1 Purpose of Study

This Flood Insurance Study investigates the existence and severity of flood hazards in the City of Sauk Centre, Stearns County, Minnesota, and aids in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. This study will be used to convert the City of Sauk Centre to the regular program of flood insurance by the Federal Insurance Administration (FIA). Local and regional planners will use this study in their efforts to promote sound flood plain management.

In some states or communities, flood plain management criteria or regulations may exist that are more restrictive or comprehensive than those on which these Federally-supported studies are based. These criteria take precedence over the minimum Federal criteria for purposes of regulating development in the flood plain, as set forth in the Code of Federal Regulations at 44 CFR, 60.1 (d). In such cases, however, it shall be understood that the state (or other jurisdictional agency) shall be able to explain these requirements and criteria.

1.2 Authority and Acknowledgements

The source of authority for this Flood Insurance Study is the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.

The hydrologic and hydraulic analyses for this study were performed by Toltz, King, Duvall, Anderson and Associates, Inc., for the Federal Insurance Administration, under Contract No. H-4706. This study was completed in October 1979.

1.3 Coordination

The flooding problems of the City of Sauk Centre were reviewed at a meeting in April 1978 with community officials and representatives of the FIA; the Minnesota Department of Natural Resources (MDNR); and the Study Contractor. At this meeting the stream reaches to be studied in detail were selected. A committee composed of the U.S. Army Corps of Engineers (COE), St. Paul District; the U.S. Geological Survey; the MDNR;

and the U.S. Department of Agriculture, Soil Conservation Service (SCS) reviewed and approved the results of the hydrologic analysis on August 10, 1979. Maps showing the delineation of the 100-year flood and the boundary of a maximum-encroachment floodway were presented at a meeting with city officials in September 1979. After review by the City Council, the maximum-encroachment floodway was selected without modification.

On March 25, 1980, the results of the work by the Study Contractor were reviewed and accepted at a final coordination meeting attended by representatives of the Study Contractor, the FIA, and the community.

2.0 AREA STUDIED

2.1 Scope of Study

This Flood Insurance Study covers the incorporated area of the City of Sauk Centre. The area of study is shown on the Vicinity Map (Figure 1).

The areas studied by detailed methods were selected with priority given to all known flood hazard areas, and areas of projected development or proposed construction for the next five years, through October 1984. The scope and methods of study were proposed to and agreed upon by the FIA and the City of Sauk Centre.

Flooding sources studied by detailed methods are listed below:

a. Sauk Lake, from northern corporate limits to Sauk Lake Dam; and

b. the Sauk River, from Sauk Lake Dam to the corporate limits upstream of Burlington Northern Railroad, a distance of 2.0 miles.

2.2 Community Description

The City of Sauk Centre is located in northwestern Stearns County, in central Minnesota, about 100 miles northwest of the Minneapolis-St. Paul metropolitan area. The city is surrounded by the unincorporated areas of Stearns County. The population of Sauk Centre, according to the 1970 census, is 3,750 (Reference 1).

The first settlers reached Sauk Centre in the late 1850's. The original townsite was platted in 1863, two years after establishment of the first store by Pendergast and Fish. The community was rebuilt after two disasters--a sudden flood in 1867 and a fire in March 1870. A big milestone in Sauk Centre's development was the coming of the railroad in August 1878. Settlers for miles around came to see the first train of the St. Paul, Minneapolis and Manitoba railroad that year. After the turn of the century, farming turned from wheat farming to dairying and produce as it exists today.

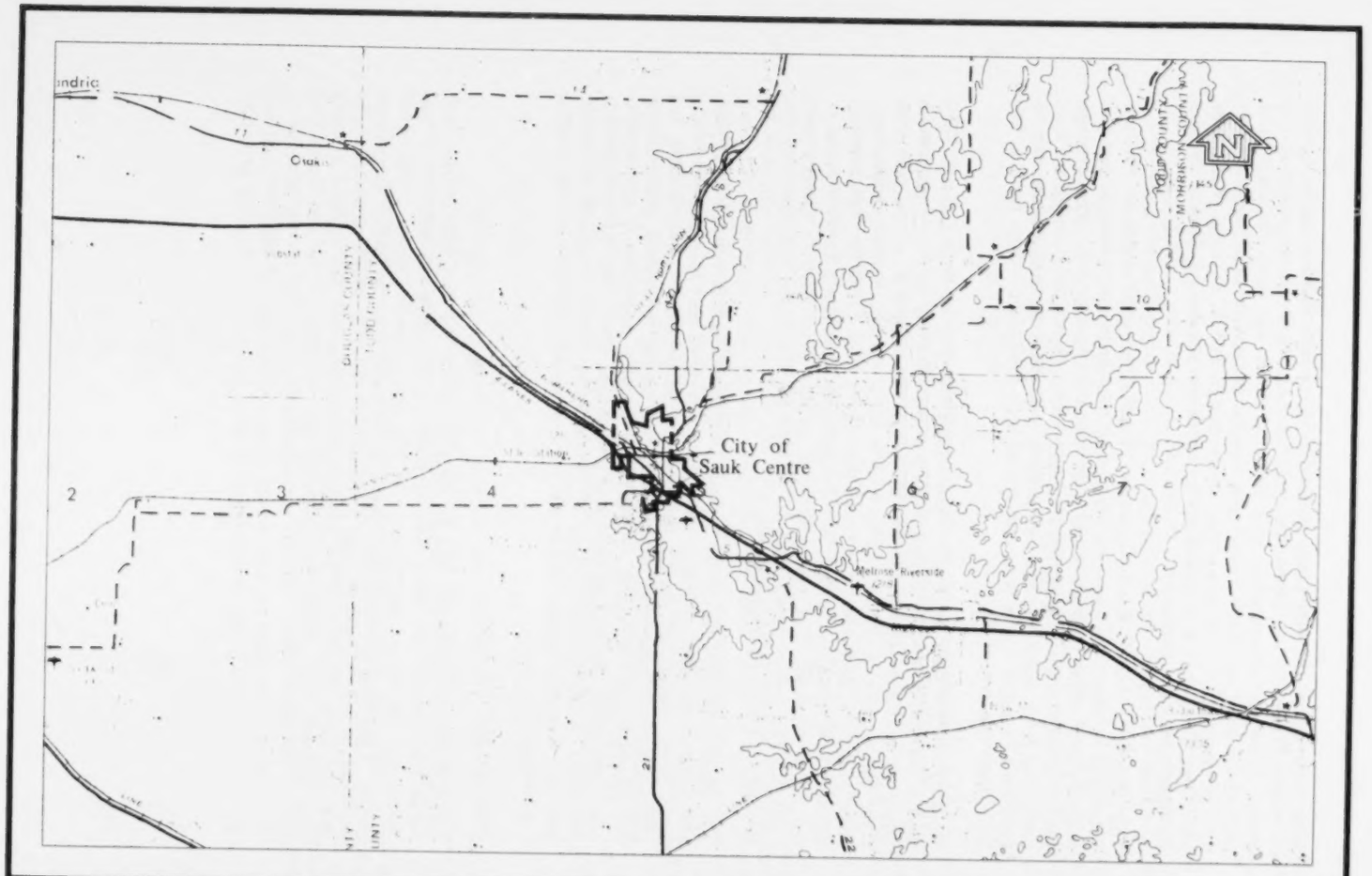

FIGURE 1

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF SAUK CENTRE, MN
(STEARNS CO.)

APPROXIMATE SCALE
4 0 4 8 12 MILES

VICINITY MAP

Sauk Centre was the birthplace and home of the late Sinclair Lewis, author of "Main Street." Mr. Lewis was the first American to be awarded the Nobel Prize for Literature. His boyhood home has been restored as a permanent museum where many memorabilia and artifacts of his early life are on display. This home has been designated a national and state historical site, and has received the coveted Award of Merit, by the National Historical Society.

The average winter temperature in Sauk Centre, December through February, is about 14 degrees Fahrenheit (F.) with the average summer temperature, June through August, at about 70 degrees F. The average yearly precipitation is roughly 24 inches with about 70 percent of that occurring from April through September. The soils in Sauk Centre can be typified as glacial till, a sand and gravel mix overlain by dark loam a few feet thick (Reference 2).

Roughly one-third of Sauk Lake lies within the City of Sauk Centre. This lake is formed behind a 12 feet high concrete gravity dam and provides a major recreational attraction for the city. Downstream of the dam, the river bed meanders to the southeast in a wide marshy, mostly undeveloped flood plain. In 1959, the river was channelized from 1,200 feet upstream of Sinclair Lewis Avenue to 200 feet downstream of Sinclair Lewis Avenue to cut off a meander that came close to private properties in eastern Sauk Centre. The river comes close to residential lots again just north of the Burlington Northern Railroad bridge.

The region contributing runoff to Sauk Centre includes Douglas, Pope, Todd, and Stearns counties. Several ice sheets advanced and retreated over the Sauk River watershed during the last glacial period. Gently rolling till plains and small morraines produced by this glacial movement characterize the geography of the region. The primary activity in the area is agriculture. There are some deposits of sand and gravel that are mined for commerical purposes. A significant portion of the drainage area is lowlands or marsh. Heavily forested areas make up only a small portion of the region (Reference 3).

2.3 Principal Flood Problems

Historic record indicates that at least twice in the last 100 years, flood water has flowed from Sauk Lake through the low area between 2nd Street North and 3rd Street North north of the dam in Sauk Centre. This event occurred during a mid-summer storm in 1867 and again in 1941, both events resulting in heavy flood damage to Sauk Centre. This overflow north of the dam has been included in the analysis of flooding for this study. Records also indicate that widespread flooding has occurred in the low areas that border the Sauk River. Due to the relatively large size of the Sauk River watershed above Sauk Centre, small, local, intense storms have little effect on the stretch of river downstream of Sauk Lake. The flooding problems

encountered in Sauk Centre are generally caused by a quick spring thaw or by a slow moving widespread frontal storm passing over the headwaters.

2.4 Flood Protection Measures

The Sauk Lake Dam provides a limited degree of flood protection for areas along the downstream reaches of the Sauk River. It was constructed prior to 1880 as a power dam for milling flour but was reconstructed in 1936 by the Works Progress Administration. Its basic function today is recreational. Control of small floods is a side benefit. The dam's spillway capacity is estimated to be sufficient to carry floods of magnitude up to at least the 10-year flood. There are no other permanent flood protection structures in Sauk Centre and none are proposed at this time.

3.0 ENGINEERING METHODS

For the flooding sources studied in detail in the community, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this study. Flood events of a magnitude which are expected to be equalled or exceeded once on the average during any 10-, 50-, 100-, or 500-year period (recurrence interval) have been selected as having special significance for flood plain management and for flood insurance premium rates. These events, commonly termed the 10-, 50-, 100-, and 500-year floods, have a 10, 2, 1, and 0.2 percent chance, respectively, of being equalled or exceeded during any year. Although the recurrence interval represents the long term average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than one year are considered. For example, the risk of having a flood which equals or exceeds the 100-year flood (one percent chance of annual occurrence) in any 50-year period is about 40 percent (four in ten), and for any 90-year period, the risk increases to about 60 percent (six in ten). The analyses reported here reflect flooding potentials based on conditions existing in the community at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

3.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish the peak discharge-frequency relationships for floods of the selected recurrence intervals for each flooding source studied in detail affecting the community.

A continuous recording stream gage is located on the Sauk River at St. Cloud, approximately 60 miles downstream of Sauk Centre. Because of the great differences in drainage area between the two locations, (960 square miles at the gage site and 360 square miles at the study area), transfer of the data from the gage site ot the study area was not considered reliable for hydrologic purposes.

For Sauk Lake and the Sauk River, the flow-frequency relationship was determined by use of the SCS hydrology TR2- computer program (Reference 4). This program uses information on the characteristics of the watershed to predict flows resulting from given runoff events. The 10-day duration rainfall from the U.S. Weather Bureau publication Technical Paper No. 49 was found to be the critical event (Reference 5). Information on the characteristics of the watershed and relevant structures in the watershed upstream of Sauk Centre was gathered from many sources. Information on the Sauk Lake Dam was provided by the City of Sauk Centre. Bridge information was obtained from the Minnesota Department of Transportation and from the County Highway Engineers in Pope, Todd, and Stearns Counties. Information on dams in the watershed above Sauk Lake was obtained from the MDNR. Flood hydrographs were then developed for Sauk River and peak discharges found for the 10-, 50-, 100- and 500-year frequency rainfall events.

Peak elevations for Sauk Lake for the selected recurrence intervals were developed through the storage routing procedures described in TR-20 (Reference 4). The Summary of Elevations for Sauk Lake are shown in Table 1.

TABLE 1 - SUMMARY OF ELEVATIONS

LOCATION	ELEVATIONS (NGVD) 10-YEAR	50-YEAR	100-YEAR	500-YEAR
SAUK LAKE				
At Sauk Lake Dam	1,228.2	1,230.6	1,231.4	1,233.1

For floods greater than the 10-year flood, part of the peak discharge shown in Table 1 bypasses the dam to flow through the low area near 2nd Street North, rejoining the river downstream of Birch Street.

Peak discharges for the 10-, 50-, 100-, and 500-year floods of each flooding source studied in detail in the community are shown in Table 2.

TABLE 2 - SUMMARY OF DISCHARGES

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (SQ MILES)	PEAK DISCHARGE (CFS) 10-YEAR	50-YEAR	100-YEAR	500-YEAR
SAUK RIVER					
Below Sauk Lake Dam	360	1,530	3,090	3,912	6,950

3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of the streams in the community were carried out to provide estimates of the elevations of the floods of the selected recurrence intervals along each flooding source studied in detail.

Stream cross section data for the Sauk River were obtained by field survey, with data for the overbank sections being obtained by photogrammetric methods (Reference 6). All bridges, dams and culverts were surveyed in detail to obtain elevation data and structural geometry.

Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles (Exhibit 1). For stream segments for which a floodway was computed (Section 4.2), selected cross section locations are also shown on the Flood Boundary and Floodway Map (Exhibit 2).

Channel and overbank roughness factors (Manning's "n") used for the streams were estimated through field inspection at each cross section. These values ranged from 0.035 to 0.060 for the channel and from 0.035 to 0.113 for the overbanks of the Sauk River. Water-surface elevations of the floods for the selected recurrence intervals were computed through the use of the COE HEC-2 step-backwater computer program (Reference 7). These computations reflected the diversion of some water to the bypass flow north of the dam during the 50-, 100-, and 500-year floods. The initial downstream water-surface elevations for the various discharges were determined using the slope-energy option of the HEC-2 program.

The overflow north of Sauk Lake Dam was also analyzed in some detail. Flood elevations were estimated through the HEC-2 computer program using two field-surveyed cross sections and a large roughness factor (0.12) reflecting the extensive development in the overflow path. The results show shallow flooding dominated by Sauk Lake downstream to approximately Pine Street, where the flooding from Sauk River downstream of the dam begins to affect the overflow characteristics.

The hydraulic analysis for this study is based only on the effects of unobstructed flow. The flood elevations as shown on the profiles are, therefore, considered valid only if hydraulic structures, in general, remain unobstructed and if channel and overbank conditions remain essentially the same as ascertained during this study.

All elevations are referenced from National Geodetic Vertical Datum of 1929 (NGVD); elevation reference marks used in the study are shown on the maps.

4.0 FLOOD PLAIN MANAGEMENT APPLICATIONS

The National Flood Insurance Program encourages state and local governments to adopt sound flood plain management programs. Therefore, each Flood Insurance

Study includes a flood boundary map designed to assist communities in developing sound flood plain management measures.

4.1 Flood Boundaries

In order to provide a national standard without regional discrimination, the 100-year flood has been adopted by the FIA as the base flood for purposes of flood plain management measures. The 500-year flood is employed to indicate additional areas of flood risk in the community. For each stream studied in detail, the boundaries of the 100-year and the 500-year floods have been delineated using the elevations determined at each cross section; between cross sections the boundaries were interpolated using flood profiles and photogrammetric methods (Reference 6). The boundaries of flooding in the overflow area north of the dam were delineated similarly, based on the limited analysis of the area. The flood boundaries for Sauk Lake were delineated photogrammetrically using the flood stages determined in the hydrologic analysis (Reference 6).

The boundaries of the 100- and 500-year floods are shown on the Flood Boundary and Floodway Map (Exhibit 2). Small areas within the flood boundaries may lie above the flood elevations and, therefore, not be subject to flooding; owing to lack of detailed topographical information or to limitations of the map scale, such areas are not shown. In cases where the 100-year and the 500-year flood boundaries are close together, only the 100-year boundary has been shown.

4.2 Floodways

Encroachment on flood plains, such as artificial fill, reduces the flood-carrying capacity, increases the flood heights of streams, and increases flood hazards in areas beyond the encroachment itself. One aspect of flood plain management involves balancing the economic gain from flood plain development against the resulting increase in flood hazard. For purposes of the National Flood Insurance Program, the concept of a floodway is used as a tool to assist local communities in this aspect of flood plain management. Under this concept, the area of the 100-year flood is divided into a floodway and a floodway fringe. The floodway is the channel of a stream plus any adjacent flood plain areas that must be kept free of encroachment in order that the 100-year flood may be carried without substantial increases in flood heights. Minimum standards of the FIA limit such increases in flood heights to 1.0 foot, provided that hazardous velocities are not produced. In Minnesota, however, flood plain encroachment is limited by Minnesota Regulations to that which would cause a 0.5 foot increase in flood heights above pre-floodway conditions at any point (Reference 8). Floodways having no more than a 0.5 foot surcharge were delineated for this study.

The floodway for the Sauk River in this study was selected by community officials in accordance with the requirements of the MDNR. The floodway

selected by community officials was then analyzed and checked for engineering accuracy by the Study Contractor to assure that it conformed to the criteria discussed previously. The results of these computations were tabulated for selected cross sections (Table 3).

No floodway was established for the overflow between 2nd Street North and 3rd Street North. This area is fully developed and therefore further encroachment is not possible. Portions of the floodway for the Sauk River lie outside of the corporate limits. The floodway concept is not applicable to lakes, because they are an area of non-conveyance, so no floodway was determined for Sauk Lake.

As shown on the Flood Boundary and Floodway Map (Exhibit 2), the floodway boundaries were determined at cross sections; between cross sections, the boundaries were interpolated. In cases where the boundaries of the floodway and the 100-year flood are either close together or collinear, only the floodway boundary has been shown.

The area between the floodway and the boundary of the 100-year flood is termed the floodway fringe. The floodway fringe thus encompasses the portion of the flood plain that could be completely obstructed without increasing the water-surface elevation of the 100-year flood more than 0.5 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to flood plain development are shown in Figure 2.

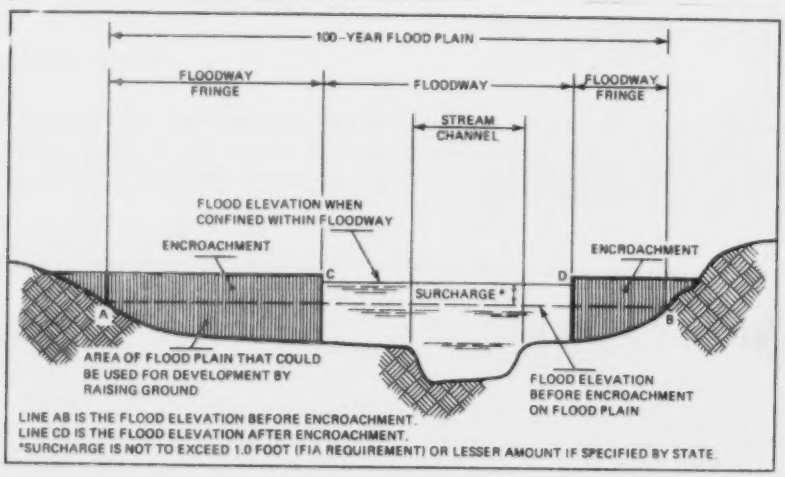
100-YEAR FLOOD PLAIN
FLOODWAY FRINGE
FLOODWAY
FLOODWAY FRINGE
STREAM CHANNEL
FLOOD ELEVATION WHEN CONFINED WITHIN FLOODWAY
ENCROACHMENT
ENCROACHMENT
C
D
SURCHARGE *
A
B
AREA OF FLOOD PLAIN THAT COULD BE USED FOR DEVELOPMENT BY RAISING GROUND
FLOOD ELEVATION BEFORE ENCROACHMENT ON FLOOD PLAIN
LINE AB IS THE FLOOD ELEVATION BEFORE ENCROACHMENT.
LINE CD IS THE FLOOD ELEVATION AFTER ENCROACHMENT.
*SURCHARGE IS NOT TO EXCEED 1.0 FOOT (FIA REQUIREMENT) OR LESSER AMOUNT IF SPECIFIED BY STATE.

FIGURE 2 - Floodway Schematic

The floodways in this report are recommended to local agencies as minimum standards that can be adopted or that can be used as a basis for additional studies.

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION		
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQ. FEET)	MEAN VELOCITY (FEET/SEC.)	WITH FLOODWAY (NGVD)	WITHOUT FLOODWAY (NGVD)	DIFFERENCE
SAUK RIVER							
A	180	243[2]	2794	1.4	1225.7	1225.2	0.5
B	980	176[2]	1843	2.1	1225.9	1225.4	0.5
C	2430	862[2]	8175	0.5	1226.0	1225.5	0.5
D	7130	1352[2]	13,728	0.3	1226.1	1225.6	0.5
E	7470	1074[2]	9910	0.4	1226.2	1225.7	0.5
F	8660	280	1846	2.1	1226.2	1225.7	0.5
G	9650	666	4842	0.8	1226.5	1226.0	0.5
H	10,630	130	1404	2.3	1226.5	1226.0	0.5

[1]FEET ABOVE BURLINGTON NORTHERN RAILROAD
[2]THIS WIDTH EXTENDS BEYOND CORPORATE LIMITS

TABLE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF SAUK CENTRE, MN
(STEARNS CO.)

FLOODWAY DATA

SAUK RIVER

5.0 INSURANCE APPLICATION

In order to establish actuarial insurance rates, the FIA has developed a process to transform the data from the engineering study into flood insurance criteria. This process includes the determination of reaches, Flood Hazard Factors (FHF), and flood insurance zone designations for each flooding source affecting the City of Sauk Centre.

5.1 Reach Determinations

Reaches are defined as lengths of watercourses having relatively the same flood hazard, based on the average weighted difference in water-surface elevations between the 10- and 100-year floods. This difference does not have a variation greater than that indicated in the following table for more than 20 percent of the reach.

Average Difference Between 10- and 100-year Floods	Variation
Less than 2 feet	0.5 foot
2 to 7 feet	1.0 foot
7.1 to 12 feet	2.0 feet
More than 12 feet	3.0 feet

The locations of the reaches determined for the City of Sauk Centre are shown on the Flood Profiles (Exhibit 1) and are summarized in the Flood Insurance Zone Data Table (Table 4).

5.2 Flood Hazard Factors

The FHF is used to correlate flood information with insurance rate tables. Correlations between property damage from floods and their FHFs are used to set actuarial insurance premium rate tables based on FHFs from 005 to 200.

The FHF for a reach is the average weighted difference between the 10- and 100-year flood water-surface elevations expressed to the nearest 0.5 foot, and shown as a three-digit code. For example, if the difference between water-surface elevations of the 10- and 100-year floods is 0.7 foot, the FHF is 005; if the difference is 1.4 feet, the FHF is 015; if the difference is 5.0 feet, the FHF is 050. When the difference between the 10- and 100-year water-surface elevations is greater than 10.0 feet, accuracy for the FHF is to the nearest foot.

5.3 Flood Insurance Zones

After the determination of reaches and their respective FHFs, the entire incorporated area of the City of Sauk Centre was divided into zones, each

having a specific flood potential or hazard. Each zone was assigned one of the following flood insurance zone designations:

Zone AH:	Special Flood Hazard Areas inundated by types of 100-year shallow flooding where depths are between 1.0 and 3.0 feet; base flood elevations are shown, but no FHFs are determined.
Zones A6 and A9:	Special Flood Hazard Areas inundated by the 100-year flood, determined by detailed methods; base flood elevations are shown, and zones subdivided according to FHF.
Zone B:	Areas between the Special Flood Hazard Area and the limits of the 500-year flood, including areas of the 500-year flood plain that are protected from the 100-year flood by dike, levee, or other water control structure; or areas subject to certain types of 100-year shallow flooding where depths are less than 1.0 foot; and areas subject to 100-year flooding from sources with drainage areas less than 1 square mile. Zone B is not subdivided.
Zone C:	Areas of minimal flooding.

Table 4, "Flood Insurance Zone Data," summarizes the flood elevation differences, FHFs, flood insurance zones, and base flood elevations for each flooding source studied in detail in the community.

5.4 Flood Insurance Rate Map Description

The Flood Insurance Rate Map for the City of Sauk Centre is, for insurance purposes, the principal result of the Flood Insurance Study. This map (published separately) contains the official delineation of flood insurance zones and base flood elevation lines. Base flood elevation lines show the locations of the expected whole-foot water-surface elevations of the base (100-year) flood. This map is developed in accordance with the latest flood insurance map preparation guidelines published by the FIA.

6.0 OTHER STUDIES

The Study Contractor for the Stearns County Flood Insurance Study developed 10-, 50-, 100-, and 500-year discharges for the Sauk River as far upstream as the City of Richmond. Discharges at Richmond were developed by transfer of gaging

FLOODING SOURCE	PANEL[1]	ELEVATION DIFFERENCE[2] BETWEEN 1.0% (100-YEAR) FLOOD AND			FLOOD HAZARD FACTOR	ZONE	BASE FLOOD ELEVATION[3] (NGVD)
		10% (10-YEAR)	2% (50-YEAR)	0.2% (500-YEAR)			
SAUK RIVER							
REACH 1	0001	–4.6	–1.2	3.9	045	A9	VARIES–SEE MAP
SAUK LAKE							
REACH 1	0001	–3.2	–0.8	1.7	030	A6	1231

[1] FLOOD INSURANCE RATE MAP PANEL
[2] WEIGHTED AVERAGE
[3] ROUNDED TO NEAREST FOOT

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF SAUK CENTRE, MN
(STEARNS CO.)

FLOOD INSURANCE ZONE DATA

SAUK RIVER - SAUK LAKE

station data from the USGS gage at St. Cloud (Reference 9). This same method was not applied to the Sauk Centre Flood Insurance Study due to the large differences in drainage area. Richmond lies some 25 miles upstream of St. Cloud whereas Sauk Centre lies approximately 60 miles upstream of St. Cloud. A comparison of the discharges obtained for the Stearns County Flood Insurance Study (Reference 9) with those developed for the Sauk Centre Flood Insurance Study revealed no inconsistencies. The approximate flood boundaries delineated in the Stearns County Flood Insurance Study for the Sauk River do not exactly match the flood boundaries shown in this study, which are based on more detailed analyses. This study also reflects updated corporate limits for the City of Sauk Centre.

A Flood Hazard Boundary Map has been published by the Federal Insurance Administration (Reference 10). The differences between the Flood Hazard Boundary Map and this study are justified due to the more detailed nature of this Flood Insurance Study.

This report either supersedes or is compatible with all previous studies published on streams studied in this report and should be considered authoritative for the purposes of the National Flood Insurance Program.

7.0 LOCATION OF DATA

Survey, hydrologic, hydraulic and other pertinent data used in this study can be obtained by contacting the Insurance & Mitigation Division of the Federal Emergency Management Agency, One North Dearborn Street, Chicago, Illinois 60602.

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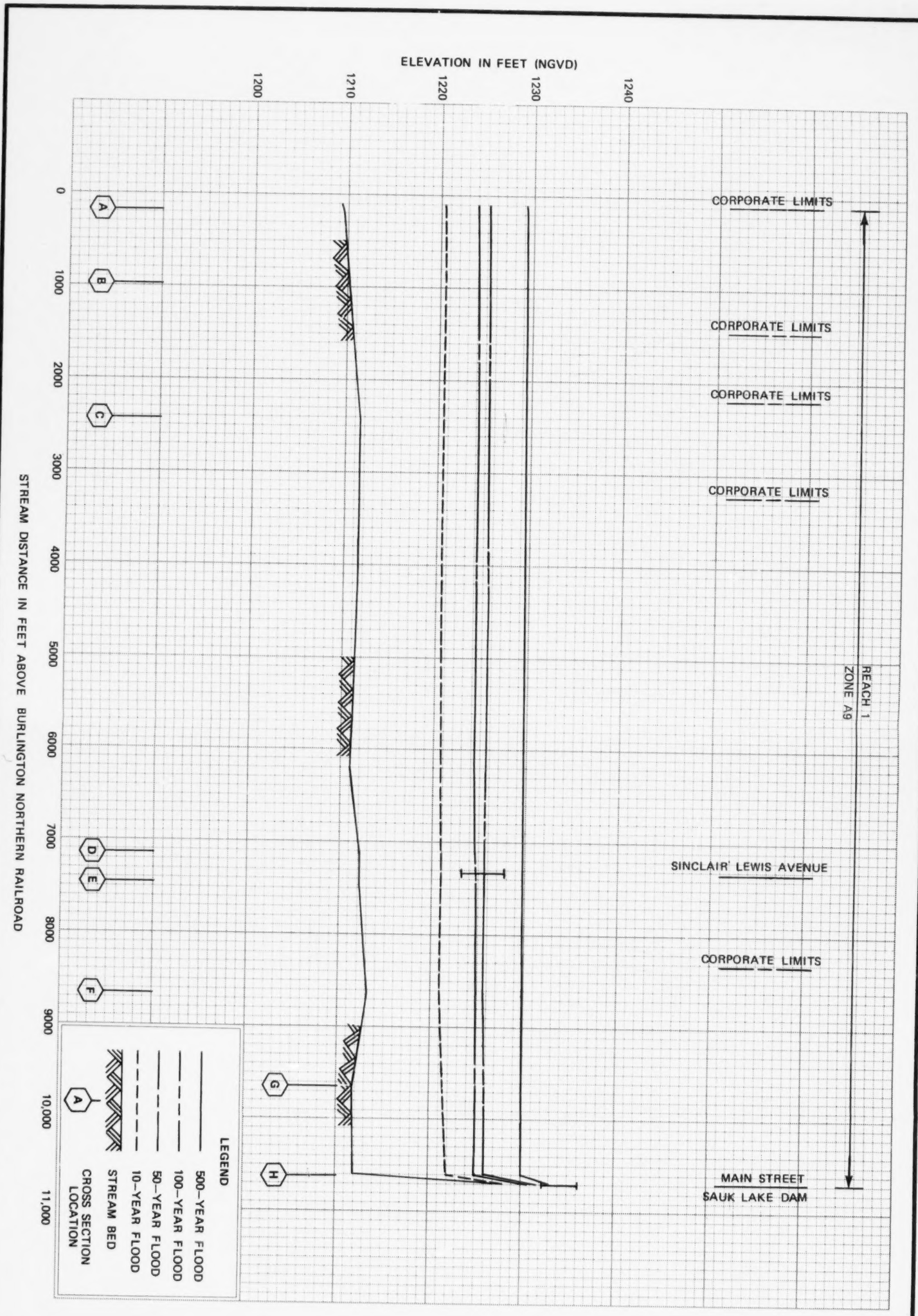

01P

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF SAUK CENTRE, MN
(STEARNS CO.)

FLOOD PROFILES

SAUK RIVER